Particle Size Distribution and Settling Velocities in Coastal Mixing and Optics Program

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LONG-TERM GOAL

My long-term goal is to characterize particle dynamics in a fundamental way, through the use of new instruments that are firmly grounded in physics and that produce data not previously available. The data are needed by modelers of sediment transport.

OBJECTIVES

Within the Coastal Mixing and Optics program (CM&O), my objectives were to characterize the dynamics of particles in the inertial layer. The questions to be investigated had to do with the testing of the Rouse formulation with a size-specific measurement of particles. The test of the Rouse formulation requires the measurement of concentrations and settling velocities on a size-resolved basis, and the measurement of a 'reference concentration' at small distance off the seabed.

APPROACH

Three instrument systems were employed that combined to address the full sediment characterization suite: a LISST-100 at two elevations to characterize vertical variations in size distribution and concentration, a LISST-ST to characterize the size-dependent settling velocity distribution of particles, and an MSCAT to measure the reference concentration. Data from all systems were obtained in the first deployment August-September, 1996. Nearly continuous record of size-dependent particle concentrations were obtained at two elevations from August 1996-June 1997. The data are being analyzed.

WORK COMPLETED

The experimental phase of the work ended in June 1997. Final instrument recovery occurred in late June. All instruments were recovered in undamaged condition, except for minor corrosion damage to the coating on the optics of the MSCAT instrument.

Early analysis of the data have been carried out and reported at a number of scientific gatherings, including at AGU, at a CM&O meeting in Keystone, and most recently, at the William D. Grant memorial symposium in Woods Hole. Two papers have been submitted.

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RESULTS

I. Size Distribution: We illustrate the size distribution with the help of figure 1. A tripod with 2 LISST-100 instruments recorded the pressure, optical transmission, and size distribution at two elevations. On the left panel, the optical transmission is shown during a segment of the second CM&O deployment, (October-Dec.,1996). The lower left panel shows the rms wave-induced pressure on the bottom. The right panel shows the shape of the multi-angle scattering.

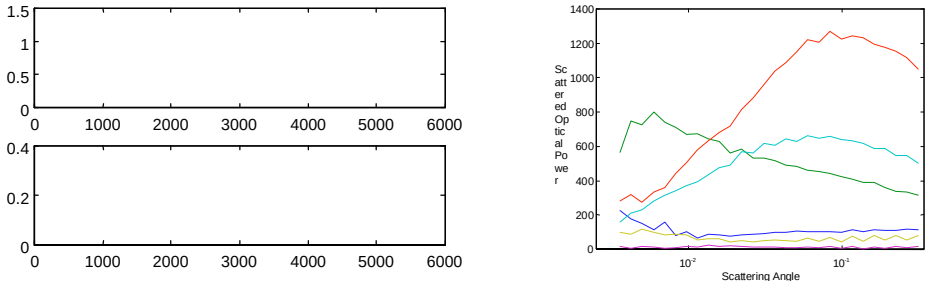

Figure 1: The optical transmission (left, upper) and 2-hour averaged rms pressure fluctuation (left lower). Pressure is shown uncalibrated . Right: angular scattering for the second major pressure event, records 2000-3000.

The strong correlation between the rms pressure fluctuation due to waves and the decrease in optical transmission establishes that the particle concentration is dependent on surface wave activity. The multi-angle scattering shows significant changes in shape, revealing the underlying changes in size distribution of particles.

Examination of data from the second deployment also reveals the order of suspension as follows: at the onset of an event, large particles (presumably flocs) appear in the water column first, followed by smaller particles, in turn followed by larger particles again. This suggests suspension of flocs, breakdown, and subsequent suspension of large bed particles. Reflocculation seems to occure quickly after the passage of a wave event.

II. Settling Velocity: The size-dependent settling velocity measurements are carried out by trapping a sample and measuring the history of size distributions evolve over time, figure 2 below. From the history, a best-fit settling velocity is determined. Data suggest departure from Stokes settling of constant density particles – possibly due to the larger particles being flocs that settle at smaller velocities.

These data can be incorporated into models that predict the relationship between bottom stress and suspended material concentration.

Reference Concentration: Although the MSCAT instrument produced measurements in the CM&O deployments, a coating on exposed optics suffered deterioration leading to progressive degradation in the quality of data. With careful analysis, the data shall be salvaged to help parameterize the reference concentration.

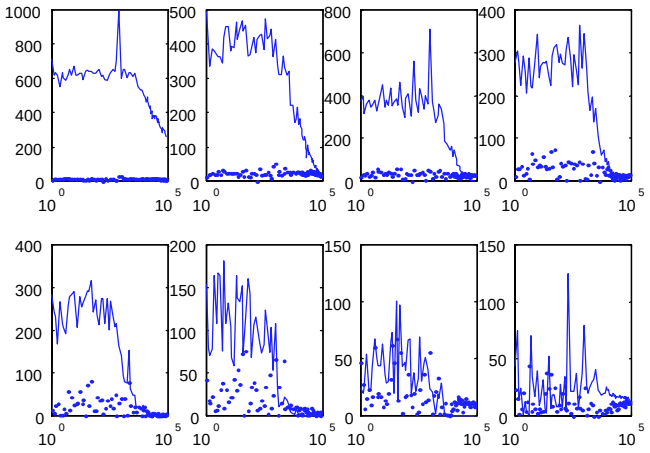

Figure 2: (From top left) Time history of concentration of 8 size classes in a settling column. The fine particles fall through the 30cm column slowly, vice versa. The dots represent noise in estimates of concentration. The data yielded settling velocities for 6 size classes. The size classes were centered at (left –right, top): 6.6, 11.8, 21.1, 37.5, 66.7, 118.6, 211 and 375 microns.

IV. A new concept sensor for Sediment Concentration: A new sensor LISST-25 has been developed in related work that overcomes the fundamental problem of prior sensors: size-dependent calibration. This laser sensor employs a special focal plane detector, and has been demonstrated to maintain calibration for a wide type and size range of particles.

IMPACT/APPLICATION

The observations of size distribution reveal previously unknown mechanisms, they reveal the destruction of particles by turbulence, and they provide the previously unknown in-situ settling velocities of particles. These observations constitute the full suite of data needed to test and advance boundary layer sediment transport models. The LISST-25 will significantly advance the correct measurement of suspended sediments.

TRANSITIONS

The LISST-100, LISST-ST and LISST-25 instruments are part of the product line of Sequoia Scientific, Inc..

RELATED PROJECTS

1. Wave Boundary Layer dynamics and sediment transport at LEO-15; funded by NURP.
2. Laser Sensor for Dissipation Rate studies in the bottom boundary layer; NSF.

PUBLICATIONS

Agrawal, Y.C., Pottsmith, 1998: Instruments for Particle Size and Settling Velocity Observations in Sediment Transport, Marine Geology (*accepted with revision.*) .

Dickey, T.D., Chang, G.C., Agrawal, Y.C., Williams, A.J. and P.S. Hill, 1998: Sediment resuspension in the wakes of Hurricanes Edourard and Hortense, Marine Geology, (in press) .